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FULL LENGTH ARTICLE

Effect of harvesting and drying methods of seedless barberry on some fruit quality

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Abstract Barberry species (*Berberis vulgaris* L. var. asperma) is cultivated in arid and semi arid areas of Iran (Southern Khorasan) and it is widely used as a food additive. Harvesting time awareness and proper drying and harvesting methods can cause higher production quality and enhance the position of this fruit in internal and global markets. Barberry trees were harvested at different methods (branch-cutting, cluster picking and impact force) and times (mid September-late October-mid November) as well as barberry fruits were dried with different methods (shade-drying, sun-drying and industrial-drying) in order to study their effect on achieve optimal production conditions and production quality. The results showed that the bulk density of dried barberry as the criteria for puffy barberry fruits was affected by harvesting and drying methods. Branch-cut harvesting method led to yield production with the lowest bulk density (rate of 214.86 kg/m^3) and thus causing more puffy fruits. Colorimetric parameter A that shows the redness of barberry fruits had the lowest rate in sun-drying method and first harvest date, and the highest rate in shade-drying method and third harvest date. The result also, shows that the sun-drying and industrial method caused damage to barberry pigments (color quality of production is reduced). This also was confirmed via the results of sensory tests, and the Panelists gave the most points to the taken samples during the second harvest date in cluster-picking approach and the shade-drying method. The lowest scores of the Panelists were belonged to the samples taken with impact force and the first harvest date in sun-drying approach.

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1. Introduction

Barberry contains more than 660 species. One species of barberry (*Berberis vulgaris* L. var. asperma) is cultivated in arid and semi arid areas of Iran (Southern Khorasan). It is widely used as a food additive. Fruits of this species are seedless, while wild type barberries produce seeds in the same area (Kafi and Balandri, 2002).

The seedless barberry fruit has been used by various ethnic populations as food. Barberry fruits consumed in the form of jams and other preserves, sirups and wines were commonly

eaten during the Medieval times in England and western Europe (Batmanglij, 2007). Barberries were, and still are, a popular food product in the Middle East and is a major crop in Iran (Ebadi, Rezaei, and Fatahi, 2010). In Iranian and Persian cooking whole dried berries, traditionally named ''Zereshk'', are commonly added to stews (Polow) and festive rice dishes (Basan, 2006). Typically in Iran, the approximate amount of dried barberries consumed per week ranges from 0.5 to 1 g (Fatehi et al., 2005). Barberries of *B. vulgaris* L. are also preserved as jams and jellies while barberry juice is consumed for its cleansing properties and blood pressure lowering effects (Batmanglij, 2007). Dried barberries are also a popular food item in Georgia. In this country the fruits from *B. vulgaris*, locally known as ''kotsakhuri'', are added to meat dishes and used as a spice in this region (Rodov et al., 2010).

Barberry fruits are harvested by three methods: branch-cutting, cluster-picking and impact force (Anonymous, 2009). In the branch-cutting approach, branches carrying fruit are being cut by a garden scissor from the junction of the main branches. In the impact force approach, a thick cloth (fabric) is being expanded under the shrub and by waving the branches and successive strikes with a stick, barberries are scattering on the cloth and for drying the products, they are being carried to the special stacks or heaps. In the cluster picking approach, the workers separate the clusters one by one from the branches by hand. This method is time consuming and due to the sharp thorns within the branches, the harvest time for the workers is severely increased. This method is used for consuming as fresh fruits. Also drying the barberry is being done in three ways: shade-drying, sun-drying and industrial-drying. In the shade-drying approach, the fruits after the harvest are distributed or scattered on the wooden or metal scaffolds. Sun-drying approach is often used for the harvested barberries by impact force method. The fresh barberry fruits are being exposed to the sunlight around the gardens or on the house's roofs. This method contaminates the products and reduces its quality such as color and appearance. Recently, industrial dryers (cabinet) for shortening the drying time and also increasing the quality of the products were developed in the region. But most producers yet believe that the crops produced by shade-drying have the highest quality.

More than 70% of the barberry fruit is harvested using impact force method and being exposed to the sunlight for drying in which both types are the worst methods of harvesting and drying. The reason is high labor expenses of barberry harvesting using branch-cutting and also lack of places for shade and industrial drying. Although studying the sources in relation to the effects of harvest date and barberry fruits drying methods was not productive, but the results of some studies showed the effects of these two variables on other agricultural products. Effect of harvest date and drying method on jujube fruits showed that these two variables had significant effects on dried fruit quality (Azarpajooh and Mokhtarian, 2007). Duration of 120 days after flowering was more suitable than 100 days for harvesting. At this time the jujube fruit's weight, length, soluble solids and acidity are the highest. Ash drying method compared to other drying methods (on the tree and industrial) in terms of texture, color and taste of dried product was more favorable (Azarpajooh and Mokhtarian, 2007).

Comparison of different methods of harvesting and drying the figs with the experimental treatments such as (drying in the open air without a plastic cover, in glass boxes and industrial dryer at temperatures 60, 55 and 65 °C) showed a temperature of 50 °C is not enough to dry figs. The 60 °C for a period less than a day is the same as three days of drying at free air. Drying temperature of 60 °C for 12 h and at a temperature of 65 °C for 9 h yielded optimum results (Rezaee et al., 2005). Barberry products in global markets is still not known so more attention and effort to harvest and post harvest problems is needed in order to produce the highest quality product, and this product can become as a high income export product to offer to the world. For this purpose, the product must be provided for exports when it is in the best and most suitable harvesting and processing conditions Knowledge of time and proper harvesting and drying methods could help farmers to produce a global quality product. So in this research to achieve the optimum production conditions, effects of three important factors (harvest time, harvest method, drying method) on the product quality were investigated.

2. Material and methods

The study was performed using factorial statistical design with the following experimental treatments and three replications for each experiment.

Barberry fruits harvesting methods at three types; branch-cutting (cutting all the fruit branches), cluster-cutting and the impact force method (striking the branches with a stick). Three times of harvest date (mid September-late October-mid November). Three methods of barberry fruits drying; shade-drying, sun-drying and industrial-drying. Finally, the effect of experimental treatments on pigment properties, bulk density and also the sensory characteristics of barberry fruits were evaluated as follows:

2.1. Measurement of barberry pigment

First color image of barberry mass was prepared using a scanner HP G3010 model. Then the barberry pigment was measured using classified image method and Image J software. Now the more common way to measure the food color is the use of LAB. LAB is an international standard where L indicates brightness range (0–100), A (redness) and B (yellow) indicates colored compound from 0 to 120 (Leon et al., 2006).

2.2. Barberry bulk density

Puffy seedless barberry is favorite for the market so to evaluate this characteristic, the mass density of barberry fruits was measured. Measurements were done by pouring some of the barberry mass inside the scaled container, and then weighed using a laboratory scale. Dividing the mass by volume, barberry mass density of the sample was calculated. Lower mass density indicates that it is more puffier.

2.3. Sensory test

Sensory testing using experienced Panelists based on Hdvnyk five-points test done and the features such as; texture, color, smell, taste and general appearance was evaluated (Moskowitz et al., 2006).

For drying the sample to industrial-drying methods a laminated cabinet's drier was used. Barberry fruits were placed in the industrial dryer at a temperature range of 55–60 °C for 20 h.

Table 1 Results of variance analysis (mean squares).

Change resources	Degree freedom	Mean squares			
		bulk density (kg/m^3)	Colorimetric		
			L	A	B
Harvest method	2	** 624.97	504.81 ns	5.57 ns	7.25 ns
Harvest time	2	** 322.52	644.02 ns	** 63.32	** 37.60
Drying method	2	** 7896.75	396.05 ns	** 69.58	** 33.59
Harvest method * harvest time	4	75.35 ns	470.84 ns	* 26.26	* 11.54
Harvest method * drying method	4	81.11 ns	465.74 ns	12.74 ns	5.78 ns
Harvest time * drying method	4	** 545.36	494.03 ns	** 60.53	** 32.86
Harvest method * drying * harvest time	8	31.39 ns	488.32 ns	3.43 ns	2.14 ns
Error		68.33	488.89	5.61	3.50

Ns: no significant differences in 5% and 1% probability levels.
* Respectively, significant differences in 5% probability levels.
** Respectively, significant differences in 1% probability levels.

Table 2 Test results of means comparison in harvest methods using Duncan test.

Harvest method	Bulk density (kg/m^3)	L	A	B
Cutting	214.86 a	23.18 a	15.96 a	6.31 a
Cluster-picking	223.39 b	29.94 a	15.54 a	5.48 a
Impact force	215.26 a	21.89 a	15.06 a	5.36 a

Numbers with the same letters in each column suggest no significant difference in 5% probability level.

3. Results and discussion

The results of data variance analysis in Table 1 indicated that the harvest and drying method treatment, harvest date and the interaction between harvest time and drying method at 1% probability level had a significant effect on barberry bulk density. Also, the harvest date and drying method and the interaction between drying method and harvest date on one hand and between harvest method and harvest date on the other hand at 1% probability level had a significant effect on the colorimetric parameters A and B. Interactions between harvest method and harvest time had significant effect at 5% probability level on the colorimetric parameter B. Non of the Treatments had a significant effect on colorimetric parameters L.

Under the influence of each variable on the studied traits are discussed separately. The effects of each variable on the studied traits are discussed separately as follow.

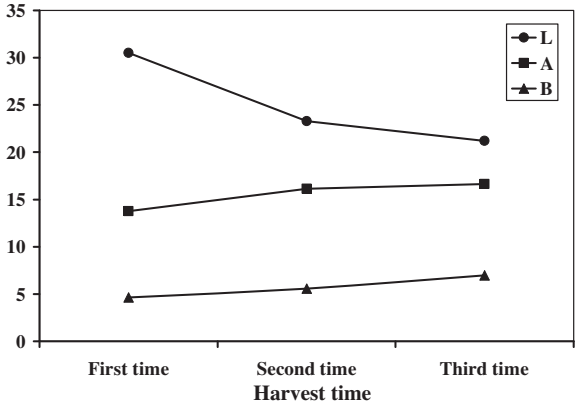

Figure 1 Effect of harvesting time on the color parameters.

3.1. Harvest method

Results in Table 2 shows that the effect of cluster-picking harvest method on increasing the bulk density compared to the other two methods of harvesting had a significant difference. Branch-cutting harvesting method had a fruit production with the least amount of bulk density '214.86 kg/m^3' and therefore had become more puffy.

Fig. 1 shows the effect of harvesting date on color product. Harvest date variable done at three levels and time intervals of 15 days. The colorimetric parameter A that represents the redness amount of barberry fruits was lowest at the first date of harvesting and had a significant difference with two other dates. Early harvesting of barberry in the first harvest date caused low redness grade of the product that gradually over time and completion of fruit growth physiology has increased and at the third harvest date reached to the value of 16.62. This result was also reported that early harvest date of jujube fruit had caused low redness grade of this product (Azarpajooh and Mokhtarian, 2007). Also, were determined that the colorimetric parameter B (indicating yellow grade) was the most at the third date and had a significant difference with the two other dates.

3.2. Drying method

Evaluation of colorimetric parameters showed that the degree of redness of dried product was under the influence of drying methods and that the industrial and sun-drying methods had lowest and highest redness rates respectively (Fig. 2).

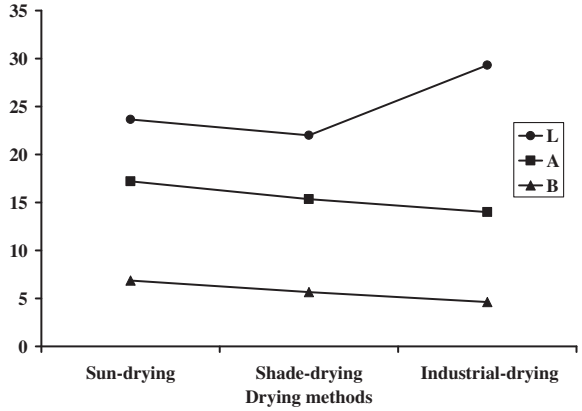

Figure 2 Effect of drying methods on the color parameters.

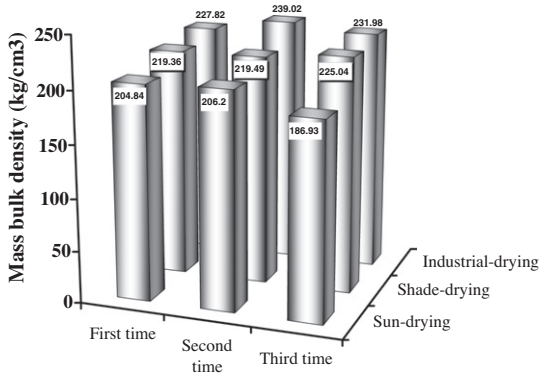

Figure 3 The interaction of harvesting time in drying method on the mass density of barberry.

On the other hand colorimetric parameters B (yellow rate) which is considered as a negative factor, was lowest in industrial method and highest in sun-drying method. This shows the negative impact of direct sunlight on color and appearance of the dried product. Similar results regarding the negative effect of direct sunlight on color quality of fig fruits has also been reported (Rezaee et al., 2005).

The interaction results in Fig. 3 show that the lowest bulk density is obtained in the third harvest date with shade-drying methods and highest mass density is related to the industrial method and the second harvest date. Important point is that the incremental process of mass density in each three harvest date from shade drying method to industrial method is considerable. Rapid transfer of moisture from the center of fruit to the membrane and from the membrane to the environment caused shortening the drying times in industrial dryers. This leaded to thermal stresses in texture and fruit membrane which caused a change in the fruit appearance (Rezaee et al., 2005). Other results also showed a significant influence of drying methods on the appearance of dried product (Chaji et al., 2008). In shade-drying due to long duration of three months for drying compared to industrial drying (20 h) and sun-drying (20 days), the product obtained is puffier and assigns higher market value.

The interaction of harvesting date with the drying method on dried fruit color characteristics indicates that the lowest colorimetric parameter 'A' took place at the first harvest date and

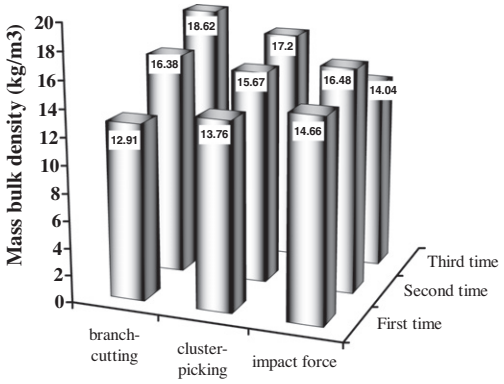

Figure 4 The interaction of harvesting time in the drying method on the colorimetric parameters A.

in sun-drying method and the highest rate occurred in shade-drying and the third harvest date. The results show that with prolonging the harvest time and maturity completion of the product, redness grade of barberry seeds has increased. Negative effect of direct sunlight on color quality of dried product can also be seen in Fig. 4.

3.3. Results of sensory test

The sensory tests to evaluate features such as texture, color, smell, taste and general appearance by using the Hdvnyk five-point test method and experienced Panelists indicated that the impact of harvesting method on texture and color parameters in the probability level of 1% and 5% respectively, and harvest date on the color in probability level of 1% and on texture, smell, taste and general appearance in probability level of 5% were significant. The effect of drying method on texture and taste in probability level of 1% and 5% were significant too.

Test results of mean's comparison showed that the highest score was given to the sensory properties related to cluster picking harvesting method. In this method, barberry texture characteristic had significant difference in the probability level of 5% with other two harvest methods (Table 3). Moreover it was also shown that significant difference between the first harvest date with second and third harvest dates in the probability level of 5% exists on all measured sensory characteristics. Lower scores being given to the barberries harvested in the first harvest date compared to other two dates, indicating incomplete physiological maturity of the product and lower quality. The same results were also obtained in same laboratory. Results showed that the sun-drying method with other two methods in the probability level of 5% had a significant difference on the taste and texture parameters. The results also showed that sun-drying with shade-drying method in the probability level of 5% had a significant difference. Panelist's lowest score was related to harvested samples in impact force method and first harvest time that were dried in sun-drying method.

4. Conclusion

Bulk density was highest in industrial-drying method and lowest in shade-drying method. Rapid drying causes shrinkage of barberry seeds. On the other hand the product obtained in

Table 3 Test results of mean's comparison at different variables levels using Duncan test.

Harvest methods	Texture	Color	Smell	Taste	General appearance
Branch-cutting	3.67 a	3.56 a	3.94 a	3.83 a	3.56 a
Cluster-picking	4.01 b	3.82 b	3.87 a	3.92 a	3.76 a
Impact force	3.49 a	3.90 b	3.88 a	3.71 a	3.49 a
Harvest time					
First time	3.53 a	3.47 a	3.67 a	3.58 a	3.43 a
Second time	3.68 ab	3.96 b	3.04 b	3.93 b	3.79 b
Third time	3.96 b	3.85 b	3.99 b	3.94 b	3.79 b
Drying methods					
Sun-drying	3.46 a	3.67 a	3.72 a	3.47 a	3.54 a
Shade-drying	3.86 b	3.89 a	3.99 a	3.01 b	3.89 b
Industrial-drying	3.85 b	3.72 a	3.99 a	3.97 b	3.58 ab

*Numbers with the same letters in each column or row indicate no significant difference in the level 5%.

longer drying time, is more puffy posture and therefore are also expected to have lower mass density.

Colorimetric parameter 'A' showing redness of barberry seeds and colorimetric parameter B representing yellow barberry seeds was the lowest in the industrial method and highest in shade-drying method and that the three methods had significant difference on each other. This result shows that in sun-drying and industrial methods because of damage to barberry seed pigments, color quality of the product is reduced. The results of sensory tests also confirmed this issue and the Panelists gave the highest score to shade-drying samples.

Results showed that the Panelists gave the highest score to the samples of cluster-picking at second harvesting time and shade drying method. And the lowest score were given by the Panelists to the samples of impact force method at the first harvest time and dried in sunlight.

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